Groundwater Storage

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Seattle, WA

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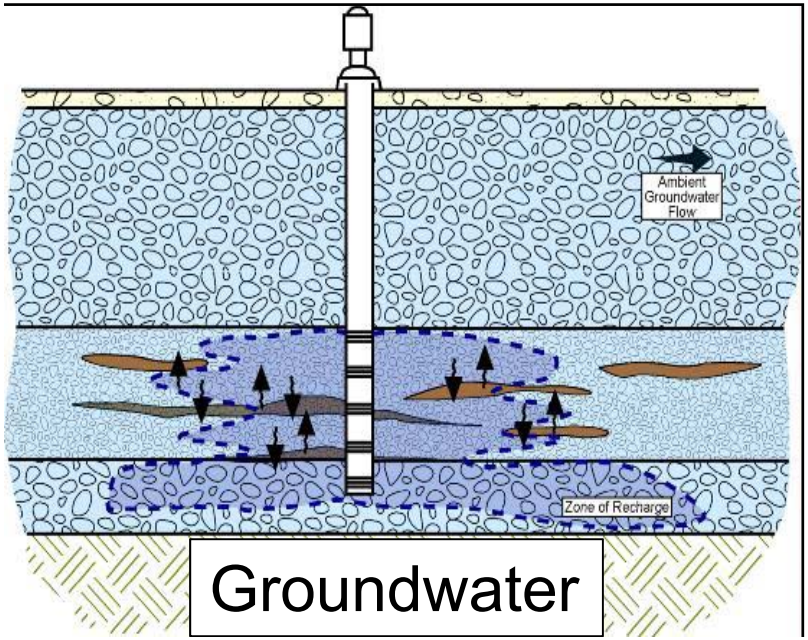
ASR

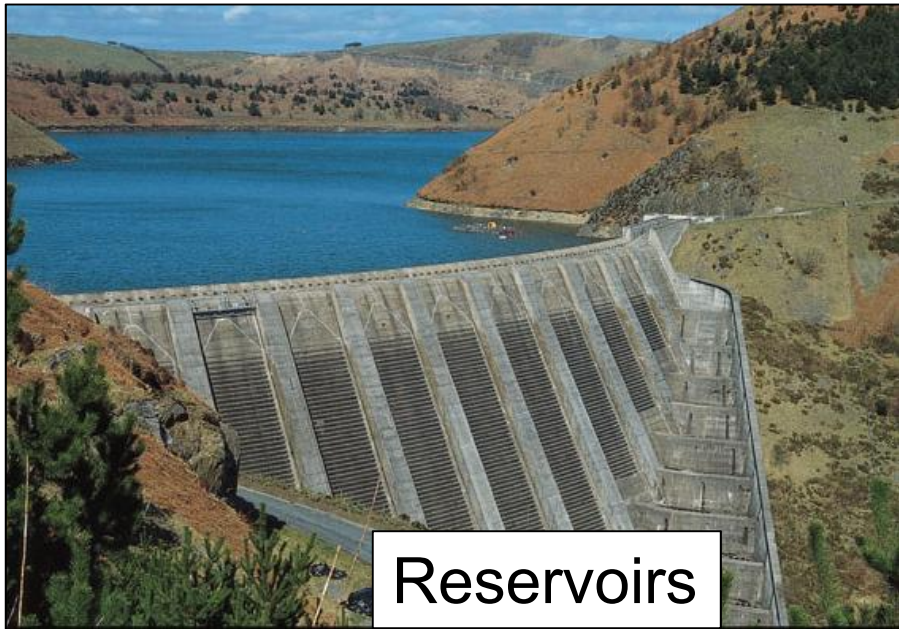
Forms of Storage

Infrastructure

Snowpack



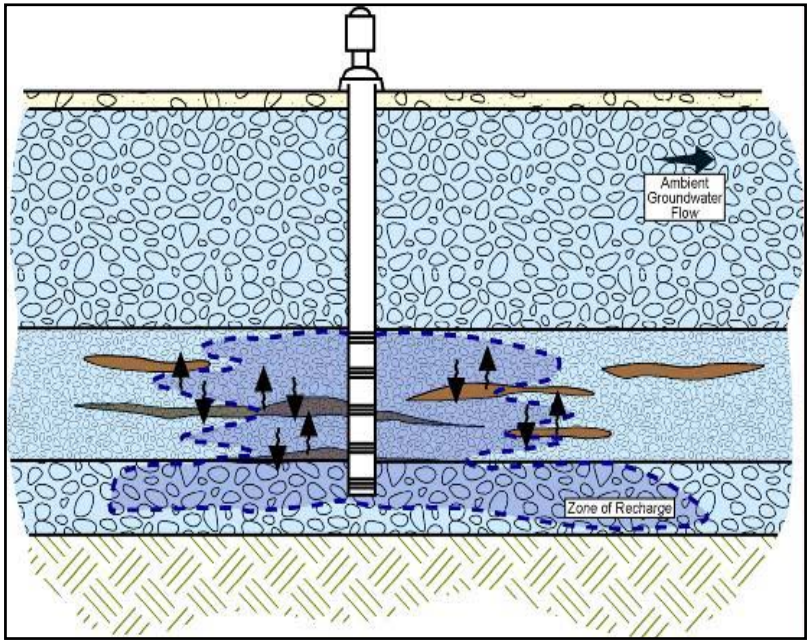
Groundwater



Reservoirs

Talk Outline

- Basics of ASR
- Water right variables
- **Recoverable quantity**
- Water quality issues
- Comparative cost
- What's needed to move forward



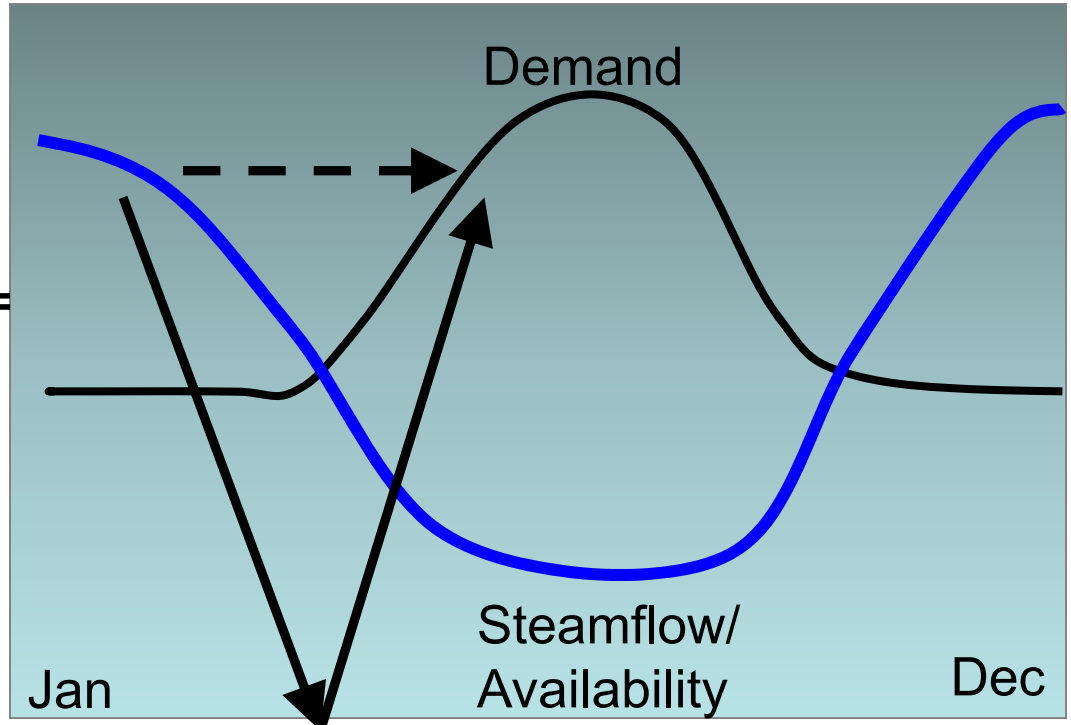
Basics for Successful ASR

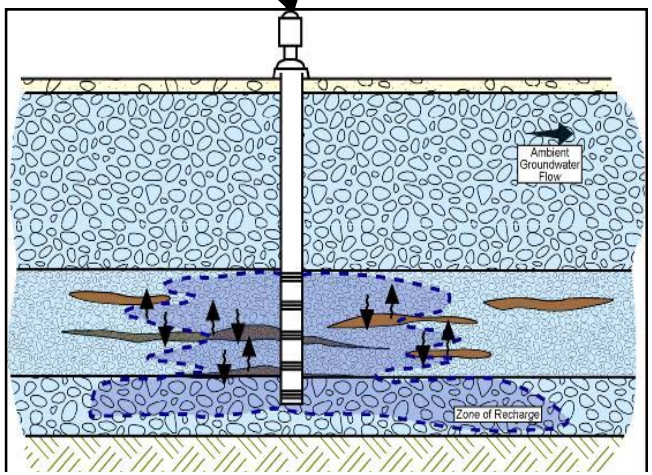
- SUITABLE AQUIFER

THIS AN ABSOLUTE MUST

The Rest Can Be Engineered

- Available water
- Compatible geochemistry
- Need or other benefit
- Adequate infrastructure
- Regulatory framework
- Opportunity





WATER RIGHT VARIABLES

- Water rights needed:
  - Primary water right for the source water to be recharged:
    - Existing (e.g., inchoate, municipal)
    - New (e.g., off season, high stream flow period)
  - Reservoir permit (RCW 90.03.270/WAC 173-157; includes secondary permit)

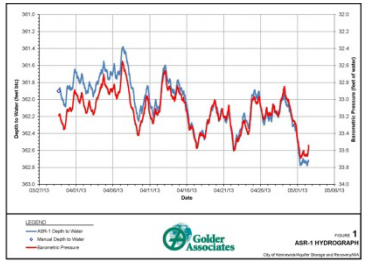
- Methods for determining the amount of water that can be recovered is not prescribed.
- This is appropriate given the range of hydrogeological settings.
- However, clarity/confidence is needed.

RECOVERABLE QUANTITY = RESIDUAL INCREASED STORAGE.

Recoverable Quantity

Do you get back what you put in?

- Recoverable quantity is a technical criteria based on water balance.
- Conceptual and computer simulation models are useful.
- Calibrated to pumping tests and long-term regional water level data.



Sometimes

- Water that seeps out/leaks away is not recoverable.
- Recoverable quantity usually decreases with time in storage.
- **Water can remain in storage for years.**

Recoverable Quantity - Examples

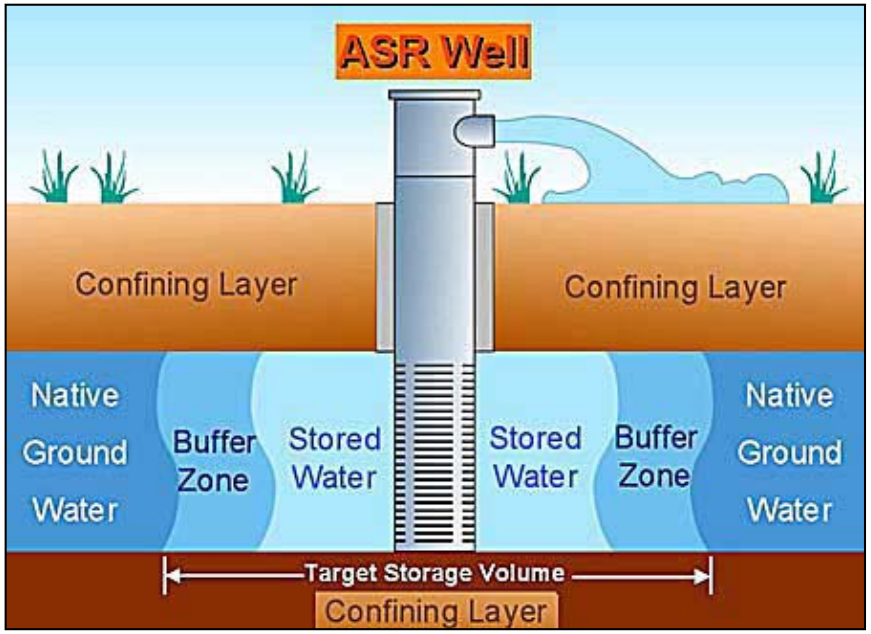
- Well-contained areas = high recoverable quantity:
  - Mined groundwater areas (low recharge in; storage created)
  - Geologic structural controls (e.g., basins, block-faulted basalt)

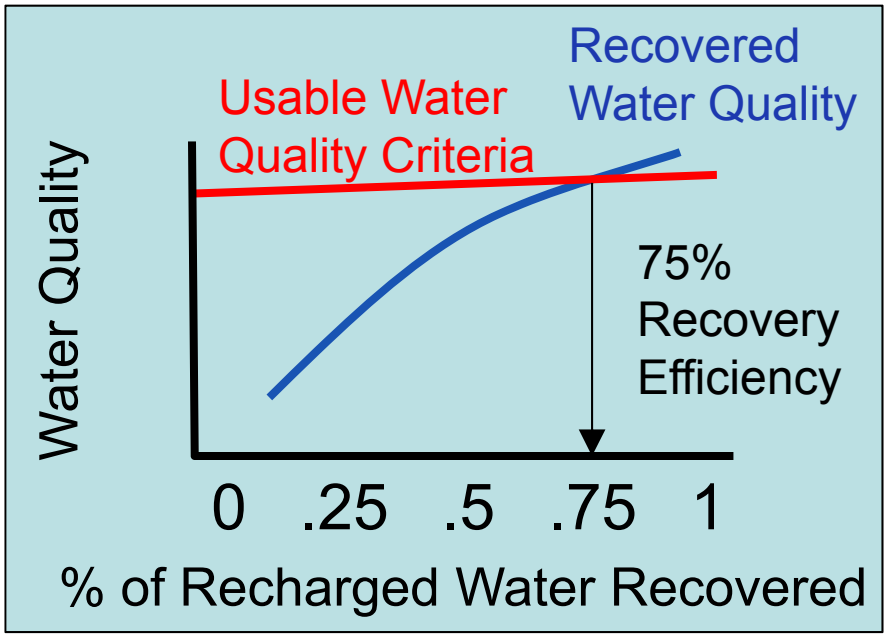
- Walla Walla, TVWD **(basalt)**: >90% (@1 yr; modeled, validated)
- Yakima **(Sandstone)**: 95% (@1 yr)
  60% (@10 yrs; modeled)
- Walla Walla **(sand & gravel):** 33% (@1 year; seepage augments streamflow)

- Oregon routinely permits 95% recovery without involved analysis – and allows carry-over of credits from year to year.

Recovery Efficiency ≠ Recoverable Quantity

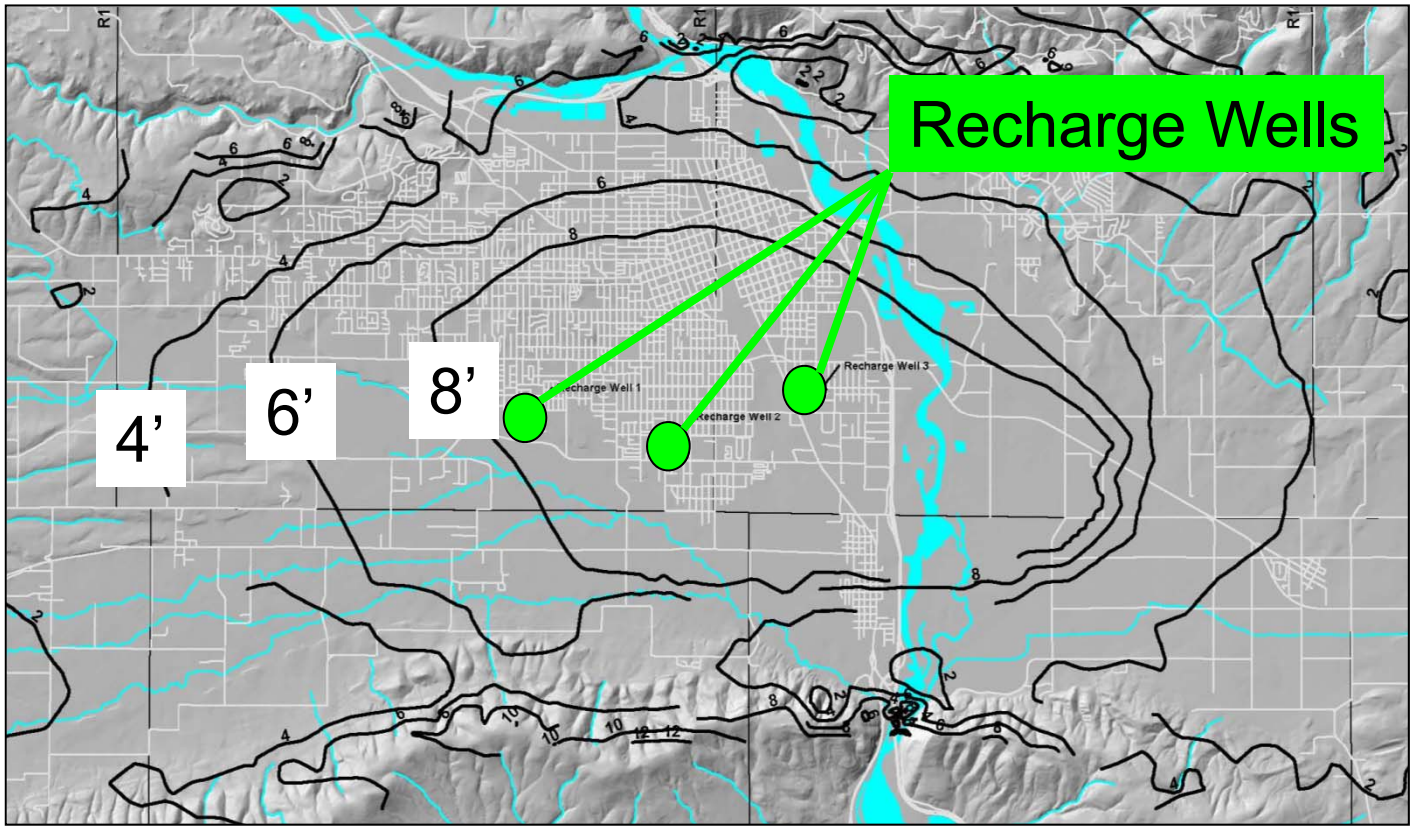
- Recovery efficiency is based on usable water quality.
- E.g., when storing fresh water in brackish systems.





Water Rights:	Water Quantity	=	Recoverable quantity
Water Use/Purpose:	Water Quality	=	Recovery efficiency

Total Storage after 10 years (YBIP)
(deep Ellensburg Fm. Ahtanum Valley)



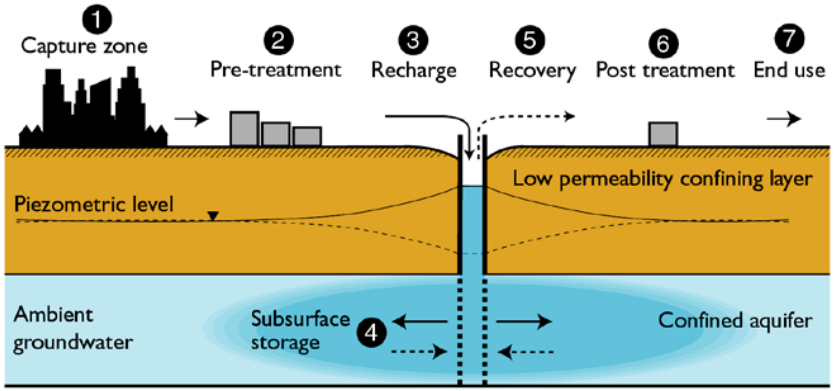
Water level rise (feet) after 10 yrs of seasonal injection and no recovery.

50,000 af recharged – 30,000 af remains in storage = 20,000 af leaks to stream

Points of Recovery

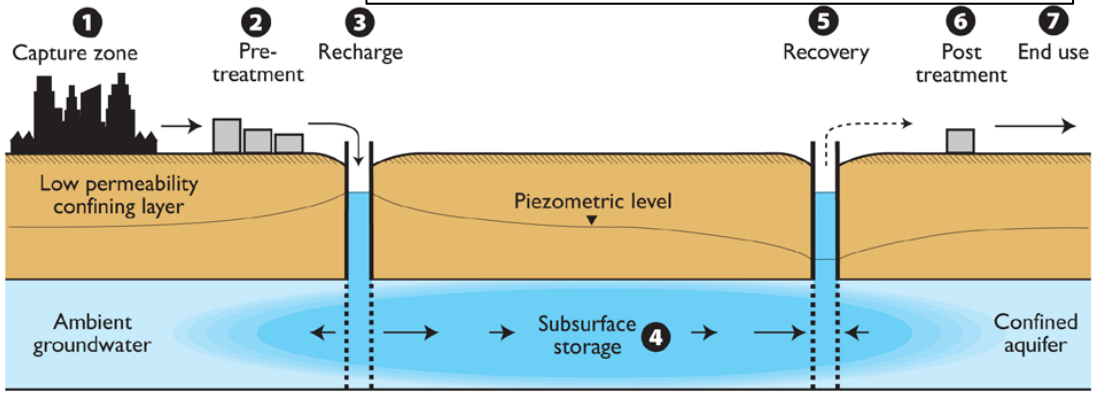
Aquifer Storage, TRANSFER and Recovery (ASTR)

- Recharge in one part of the basin
- Recovery in other parts of the basin – a water balance basis
- Recovery of same molecule not required – and may not be preferred, e.g.:
  - Stormwater
  - Reclaimed water
  - "Indirect Potable Reuse"
  - Used in California, Australia



ASR: Recharge and recovery in **same well**

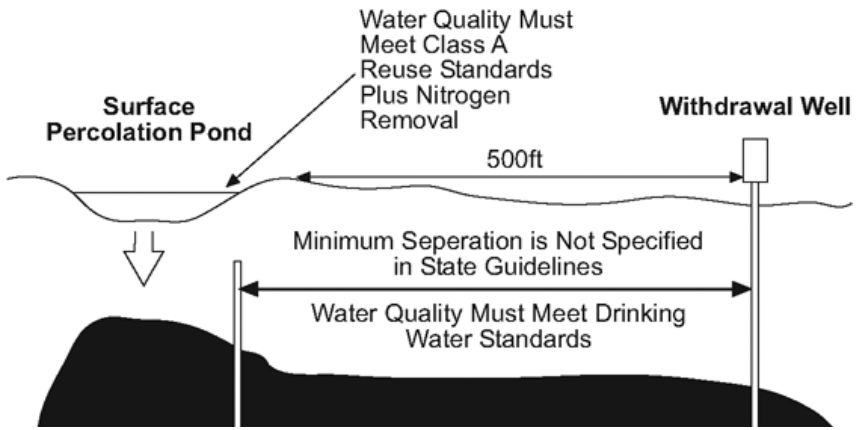
ASTR: Recharge and recovery in **different wells**



Reclaimed Water Recharge

Technical Issues

- Production is constant – Demand is typically variable
- Groundwater recharge provides complementary balance
- Requires nitrogen removal



Water Right Issues

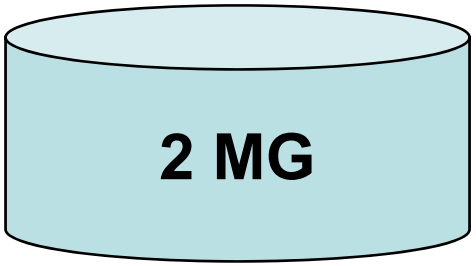
- Must respect streamflow reliance on existing discharges
- Can mitigate impacts from new withdrawals
- New water right if it is water balance neutral

Regulatory Issues

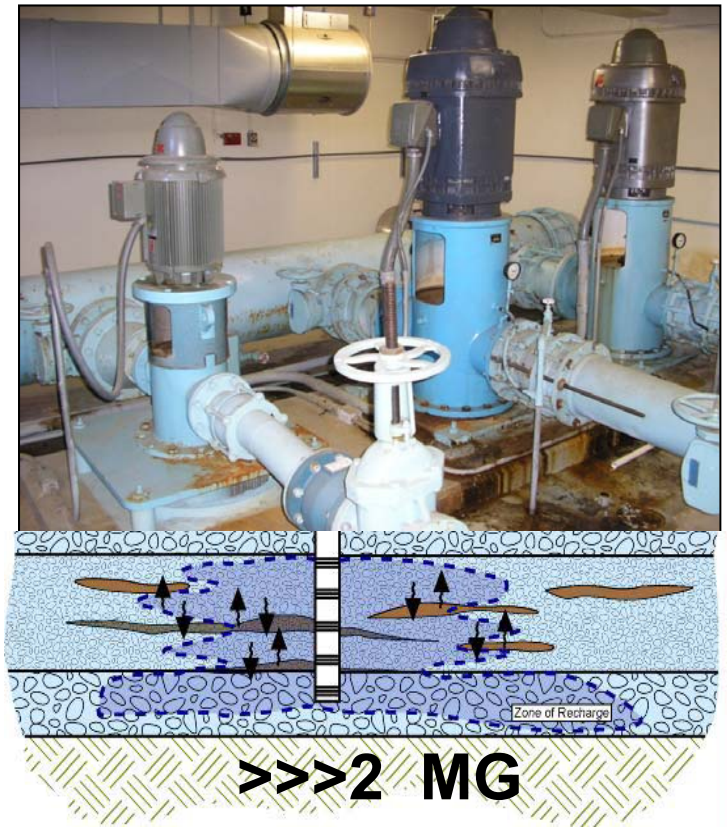
- Guidelines exist
- Draft rule in preparation (WAC 173-219)
- Refers to WAC 173-200 criteria
- Local rules may also apply (e.g., county)

Water System Operations

- Storage needed for fire flow, backup, emergency.

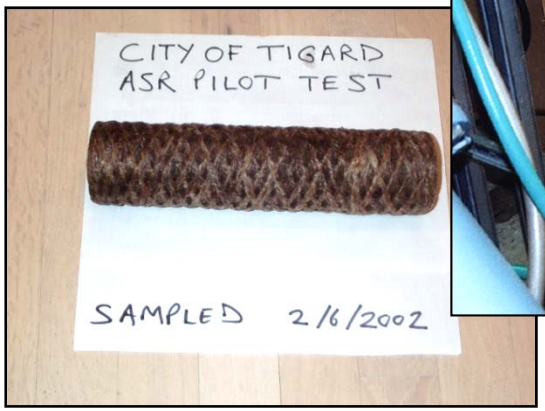


- Conventional storage:
  - ~$2M, 2 MG, ½ day supply*
- ASR (per well):
  - ~$2M, indefinite supply*
- Allow new wells for system reliability/balance.

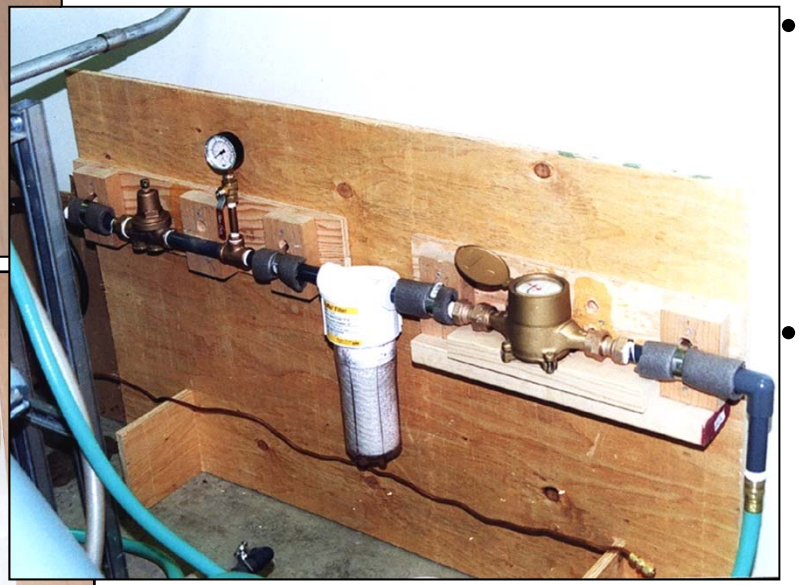


*@3,000 gpm

CLOGGING



System Scale



- **Source Water Suspended Sediments** – Control with source water filtration.
- **System scale** – Control with system flushing.

System Flushing

- **In-well sediment clogging –** Sometimes easily reversed by back flushing of well.
- **Biofouling** – control with disinfection.

Major Water Quality Considerations

1. **Operational** (clogging):
   - **Biofouling** – prevent with residual chlorine.
   - Suspended sediment – prevent by system flushing O&M.
   - Air entrainment – prevent with full pipe flow
2. **Regulatory**
   - Anti-degradation of Groundwater (WAC 173-200; e.g., disinfection products)
   - Drinking Water (e.g., release of heavy metals from sulfide mineral oxidation)

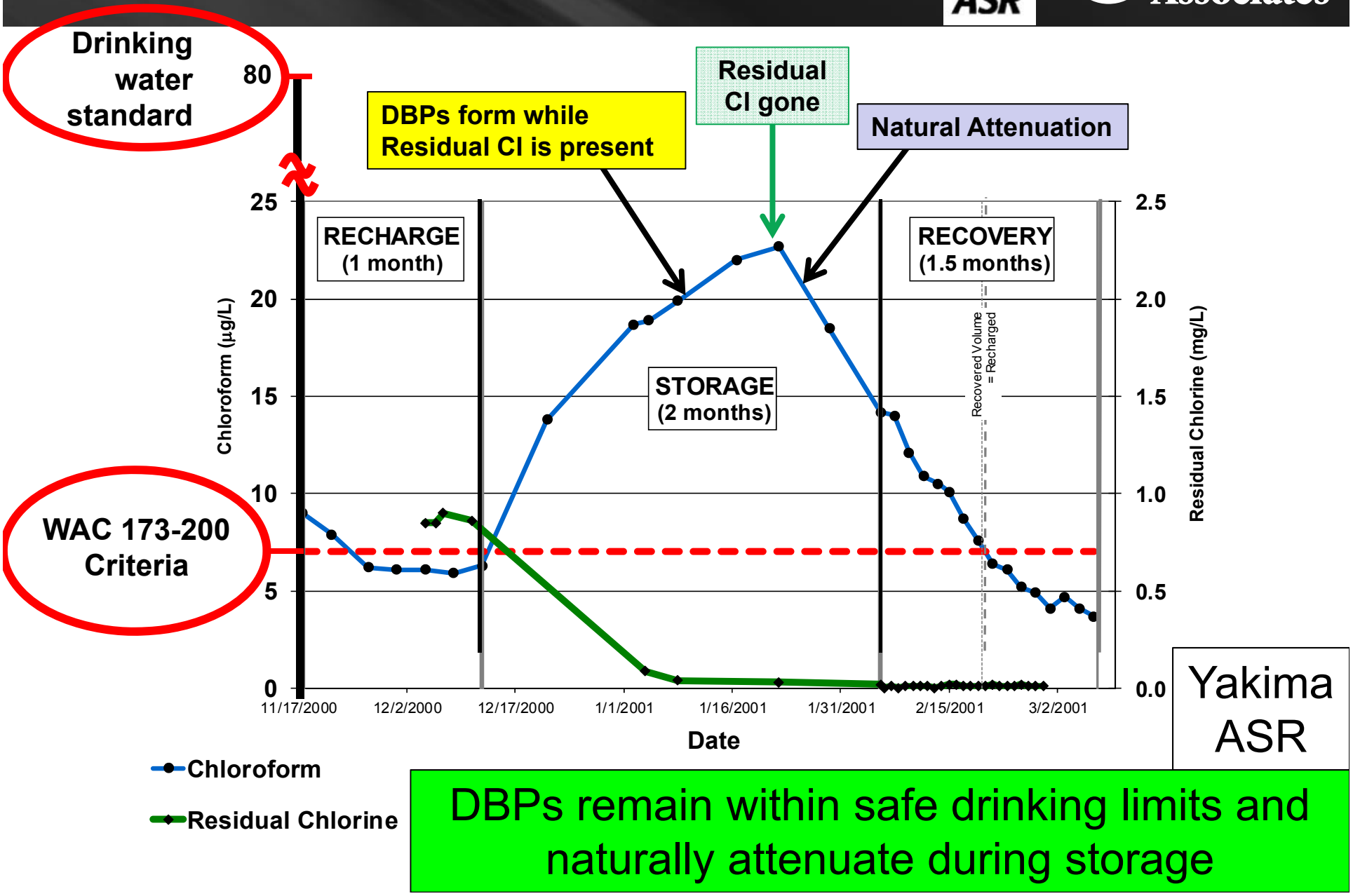
Tigard, OR Recharge

Anti-Degradation of Groundwater
(WAC 173-200)

- Chlorination DBPs are a concern (e.g., TTHMs)
- Trichloromethane regulatory limits:
  - Federal SDWA: 80 ppb (as TTHM)
  - Oregon ASR: 40 ppb (as TTHM; 50% of SDWA)
  - WAC 173-200: 7 ppb (as Trichloromethane)
- 15-50 ppb Trichloromethane is typical in chlorinated drinking water
- **AKART** analysis – Treatment is expensive, and may add costs for biofouling control.
- **OCPI** is used to allow variances – requires 5 year reviews.

DBPs = Disinfection byproducts
TTHM = total trihalomethanes
RO = Reverse osmosis
AKART = All Known Available and Reasonable Technologies
OCPI = Overriding Consideration in the Public Interest

Chlorination Disinfection DBPs



DBPs remain within safe drinking limits and naturally attenuate during storage

Reactions in the Aquifer

- Oxygenated recharge water

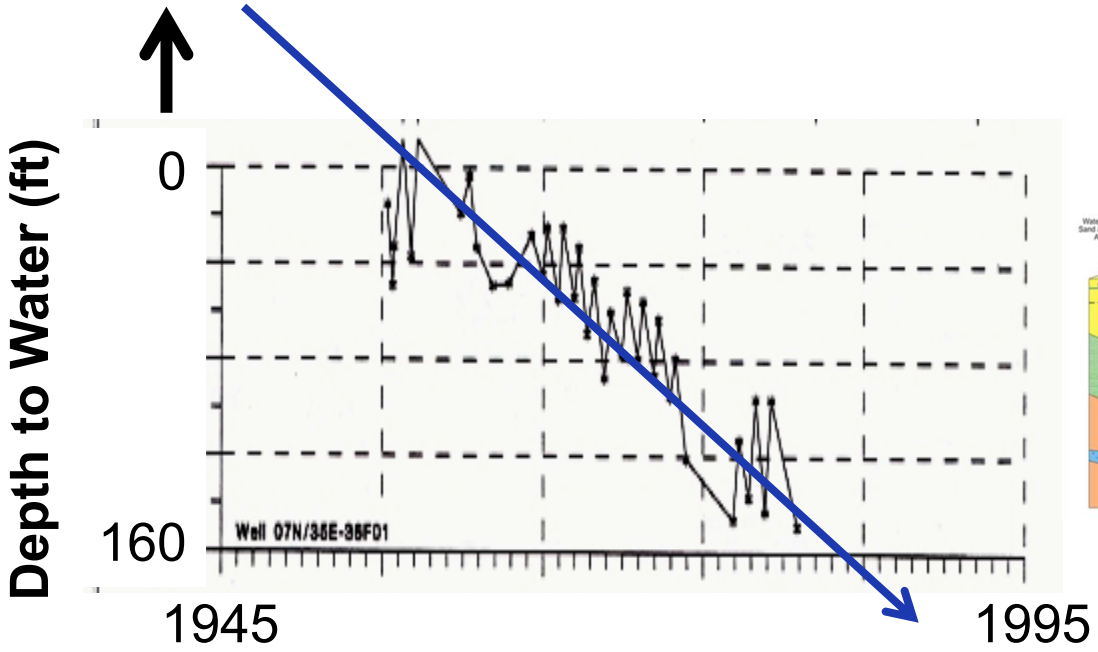
  + reduced aquifer minerals

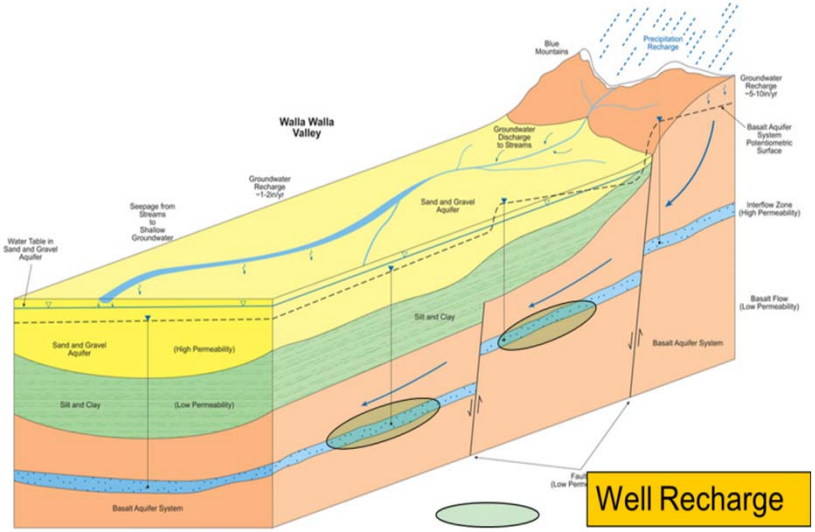
  = Oxidation of sulfide minerals?

- *Potential* release of trace elements (e.g., As)
- Has happened in other areas (e.g., FL [Arsenic], WI [Cobalt])
- Has not happened yet in the PNW.

Walla Walla – Setting

- 1900s: Groundwater levels dropped (agriculture).
- 1940s: Population growth strains Mill Creek water supply.
- 1940s-1960s: City drills wells.
- 1950s: USGS tried ASR – fails (clogging & cascading water).
- 1999: City starts ASR program (for peaking, backup, emergency).



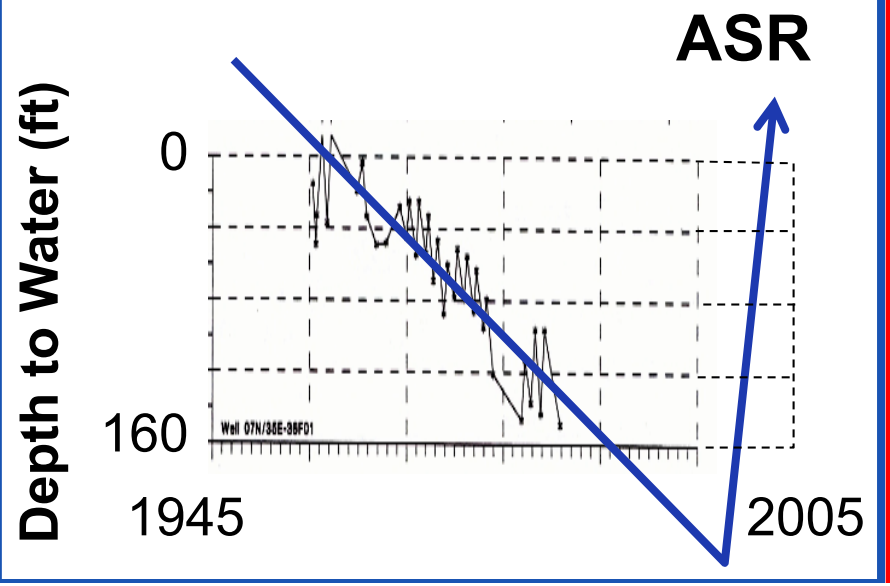


Block-faulted basalt

Walla Walla – ASR Program

- Recharge water is not filtered (control turbidity, recharge at high rates)
- Recovery when Mill Creek has:
  - High turbidity
  - Low streamflow
- Groundwater levels have been restored.
- 2005: ASR application submitted (>90% recovery modeled).
- Part of city's sustainable water program.

Reclaimed water for irrigation & spring creek flows



In-line hydropower

Cost Comparisons

- Conventional water costs:
  - Water right: **$1,000-$10,000**/afy (water market)
  - Seasonal storage: **$6,000/af** (Wymer)
  - Infrastructure storage: **$2M** (2 MGD)

- ASR costs:
  - Water right: **$0.5M?** (water right processing)
  - Seasonal storage: **Zero** (using Mother Nature's aquifer)
  - Infrastructure storage: **$2M** (per 4 MGD well)

IN CONCLUSION

ASR

- Can increase reliability of supply at a competitive cost.
- Is responsible water resource management with environmental benefits.

Recoverable Quantity

- Is a technical water balance question to be answered with modeling and water level data.
- Some loss should be expected.
- Real credit should not be arbitrarily lost after one year.

Water Quality

- Should not be used to determine recoverable quantity.
- A process for variance from WAC 173-200 should be maintained (OCPI or Legislative fix).

Thank you!